



Cairo Air Improvement Project
Compressed Natural Gas Component

**Natural Gas as an Alternative to
Diesel Fuel, An Assessment of Pricing
Alternatives**

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USAID/Egypt, Office of Environment
USAID Contract No. 263-C-00-97-00090-00

September 1999

Table of Contents

Title	Page
List of Tables	iii
List of Figures	iii
Introduction	1
Background	1
Purpose and Scope	3
Available Data	4
Assumptions	4
Results	5
Recommendations	8
Program Implementation	8
Possibilities for the Future	9

List of Tables

Table	Title	Page
1	Diesel Fuel Consumption, 1981–2008	2
2	Fuel Prices Raised by Various Factors	5
3	CNG Sections to be Constructed from Increased Revenue from Diesel Fuel Sales	6
4	Summary of Diesel Fuel/CNG Study	9

List of Figures

Figure	Title	Page
1	Diesel Fuel Consumption	3
2	Diesel Fuel Price According to Different Assumptions	6
3	Number of CNG Stations that Can be Constructed from Increase of Diesel Fuel Price	7
4	Capacity of Constructed CNG Fuel Stations per Year	7
5	Fuel Demand and Actual Amount of Diesel and CNG Consumed	10

Introduction

Energy is the cornerstone of economic development and the basis for a nation's progress and prosperity. The demand for energy has increased tremendously to satisfy technological needs and lifestyle changes in a world of increasing population and sophistication.

Conventional energy resources from petroleum products are being depleted, leaving no choice but to turn to alternative fuels.

The Government of Egypt is executing an optimistic development strategy to modernize the infrastructure in the country and is implementing projects such as the Toshka Valley, the Sinai Development Project, the North of Suez Gulf Project, and the Suez Canal Branch Project. As part of its strategic development plan, the government is giving special attention to energy generation and conservation as well as protection of the environment. Energy generation is currently escalating to keep up with the fast pace of expansion in the industrial, infrastructure, and transportation sectors. The government is also giving attention to issues related to improving air quality in urban areas, especially Greater Cairo.

To satisfy both the need to use alternative fuels and the government's growing concern with quality of life, the demand for compressed natural gas (CNG) is growing fast. It is one of the cleanest burning fuels available and is suitable for both vehicle engines and industrial applications. Traditional diesel fuels, on the other hand, produce large amounts of suspended particulates that constitute a health hazard. In addition, expanding the use of diesel fuel increases the burden on the government, because diesel is a subsidized commodity.

Background

The harmful effects of burning diesel fuel to the ecological system and to health are well known and documented. Nevertheless, diesel fuel consumption increased from 2.6 million tons in 1981–82 to 6.2 million tons in 1997–98. In other words, diesel consumption has nearly tripled in the past 15 years and is expected to reach 8.3 million tons by the year 2002–03, as shown in Table 1 and Figure 1. The table and figure were developed by calculating average fuel consumption in the years 1981–82, 1997–98, and 20002–03.

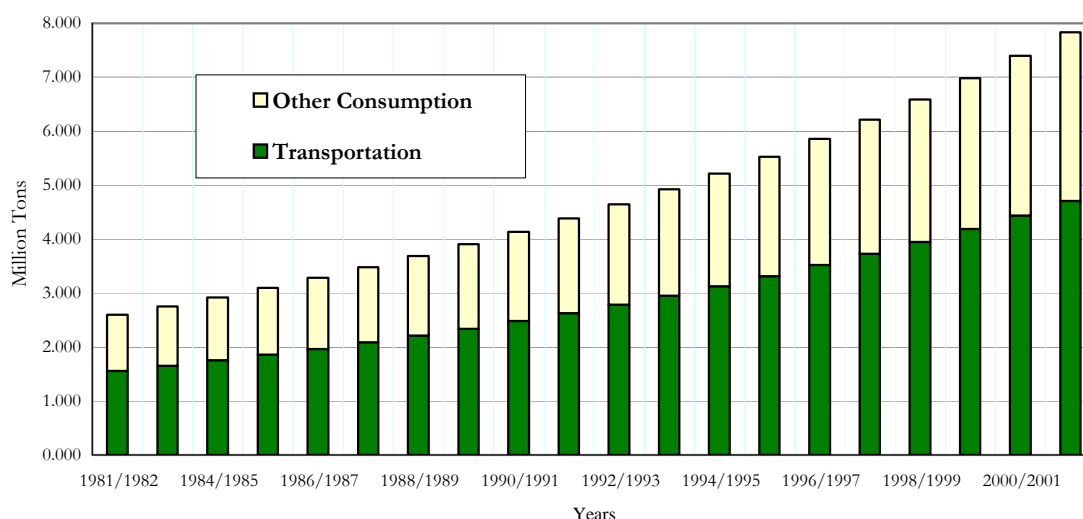
The government imports and subsidizes a high percentage of total diesel to support local demand. Imports in 1996–97 were approximately 714,000 tons, valued at LE480 million (LE672/ton). As diesel fuel is sold to the public at approximately LE400 per ton, that means that the Egyptian Government subsidy of diesel fuel is in the neighborhood of LE272 for each ton.

Egypt is exerting great efforts to balance the national budget. If the consumption of subsidized diesel fuel continues to increase at the same pace, this may impact implementation of strategic development plans for the country.

Table 1
Diesel Fuel Consumption (million tons), 1981–2008

Year	Transportation				Non-transportation	Total
	Railways	Public Bus Authorities	Other	Subtotal		
1981–82	0.080	0.040	1.440	1.560	1.040	2.600
1983–84	0.085	0.042	1.526	1.653	1.102	2.755
1984–85	0.090	0.045	1.617	1.752	1.168	2.920
1985–86	0.095	0.048	1.714	1.857	1.238	3.095
1986–87	0.101	0.050	1.817	1.968	1.312	3.280
1987–88	0.107	0.053	1.925	2.086	1.390	3.476
1988–89	0.113	0.057	2.040	2.210	1.474	3.684
1989–90	0.120	0.060	2.162	2.343	1.562	3.904
1990–91	0.127	0.064	2.292	2.483	1.655	4.138
1991–92	0.135	0.067	2.429	2.631	1.754	4.385
1992–93	0.143	0.071	2.574	2.788	1.859	4.647
1993–94	0.152	0.076	2.728	2.955	1.970	4.925
1994–95	0.161	0.080	2.891	3.132	2.088	5.220
1995–96	0.170	0.085	3.064	3.319	2.213	5.532
1996–97	0.180	0.090	3.247	3.518	2.345	5.863
1997–98	0.191	0.096	3.441	3.728	2.485	6.213
1998–99	0.203	0.101	3.647	3.951	2.634	6.585
1999–00	0.215	0.107	3.865	4.187	2.792	6.979
2000–01	0.228	0.114	4.096	4.438	2.958	7.396
2001–02	0.241	0.121	4.341	4.703	3.135	7.838
2002–03	0.256	0.128	4.601	4.984	3.323	8.307
2003–04	0.271	0.135	4.876	5.282	3.522	8.804
2004–05	0.287	0.144	5.168	5.598	3.732	9.330
2005–06	0.304	0.152	5.477	5.933	3.955	9.888
2006–07	0.322	0.161	5.804	6.288	4.192	10.480
2007–08	0.342	0.171	6.151	6.664	4.443	11.106

Figure 1
Diesel Fuel Consumption



The Ministries of Petroleum and of Electricity and Energy have taken serious steps to substitute CNG for diesel fuel, especially in the field of electric power generation. The Ministry of Petroleum is exploring different avenues to substitute CNG for diesel fuel in the transportation sector. These steps will open new industrial avenues, protect the environment, and relieve the Egyptian economy from the burden of subsidizing ever-increasing quantities of imported diesel fuel.

Natural gas is both abundantly available and environmentally friendly. Known reserves of natural gas have continued to increase since 1985, in contrast to oil reserves, which have remained unchanged for the last two decades. This makes CNG the logical alternative fuel for diesel, especially for the transportation sector.

CNG has already proved itself as a successful substitute for gasoline in the transportation sector in Egypt. The number of privately owned taxicabs that have converted from gasoline to CNG has exceeded all expectations. The Ministry of Petroleum is currently struggling to keep up with the tremendous demand for conversion to CNG.

Purpose and Scope

The Egyptian Environmental Affairs Agency (EEAA) requested that the CNG component of the Cairo Air Improvement Project (CAIP) submit a preliminary study on the economic aspects of replacing a portion of the diesel fuel used in Egypt with CNG.

This report represents a preliminary investigation of the economic advantages of substituting CNG for diesel fuel. It also suggests different alternatives to implement a strategy of replacing diesel fuel with CNG that the government could apply.

Available Data

The data summarized in this report was taken from a variety of government documents and from publications from the Ministry of Petroleum.

□ Diesel consumption in 1981–82	≅ 2.6 million tons
□ Diesel consumption in 1997–98	≅ 6.2 million tons
□ Estimated consumption in 2001–02	≅ 7.8 million tons
□ Annual increase in diesel consumption	≅ 6%
□ One m ³ of CNG is equivalent to	≅ 1 liter of diesel
□ Dedicated CNG fuel station annual capacity (Based on 100,000 vehicles fueled per year each with an average of 40 m ³)	≅ 4 million m ³
□ Dedicated CNG fuel station annual capacity is equivalent	≅ 4,000 tons of diesel
□ Dedicated CNG fuel section construction cost at gasoline station	≅ LE5 million
□ Diesel consumption in the transportation sector	≅ 60% of total
□ Diesel consumption in other industries	≅ 40% of total
□ Price of imported diesel fuel	≅ LE672 per ton
□ Price of diesel fuel in local market	≅ LE400 per ton
□ Government subsidies	≅ LE272 per ton

Assumptions

This study was based on diesel fuel consumption data for the last few years. In 1981, diesel fuel consumption was 2.6 million tons. By 1997, it had increased to 6.2 million tons. Projections for future diesel fuel requirements were calculated based on these figures. The price of diesel fuel is expected to reach a maximum market value equivalent to that of gasoline. Expected annual increases of 6 percent in diesel fuel consumption are taken into consideration.

These are the various possible scenarios that were analyzed:

□ Price of diesel fuel is	constant
□ Price of diesel will increase	10% annually
□ Price of diesel will increase	20% annually
□ Price of diesel will increase	30% annually

- Price of diesel increases and revenues gained from the price increase are used for converting sections of existing gasoline stations into CNG fuel sections instead of reducing the burden of the government subsidy

Results

If price increases were implemented relatively quickly, and if the price of gasoline remains constant over the period in question, the scenarios outlined in Section 3 would have these results:

- If the price of diesel increases annually by 10 percent, by 2007–08, the cost of diesel would match the cost of gasoline.
- If the increase were 20 percent annually, by 2002–03, diesel costs would match gasoline.
- At a 30 percent annual increase, diesel would cost as much as gasoline in 2001–02.

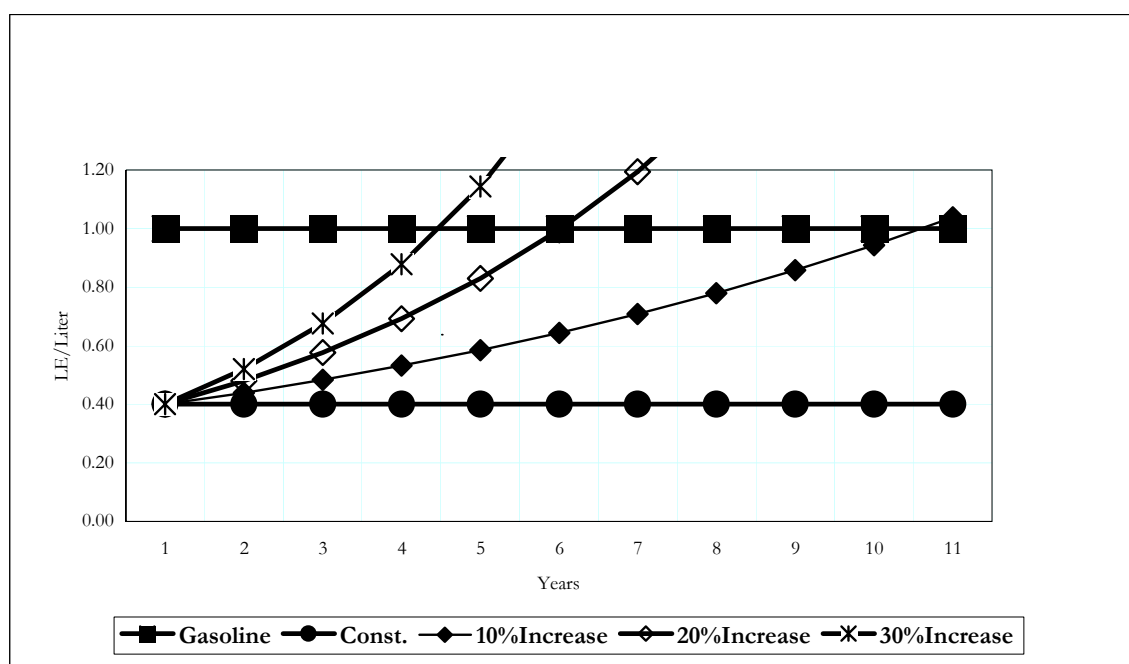
Table 2 spells this out, while Figure 2 graphically illustrates how government income would increase.

Table 2
Fuel Prices Raised by Various Factors (price LE/liter)

Fuel	Annual Price Increase	Years										
		1	2	3	4	5	6	7	8	9	10	11
		1997–98	1998–99	1999–00	2000–01	2001–02	2002–03	2003–04	2004–05	2005–06	2006–07	2007–08
Gasoline	None	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Diesel	None	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40
Diesel	10%	0.40	0.44	0.48	0.53	0.59	0.64	0.71	0.78	0.86	0.94	1.04
Diesel	20%	0.40	0.48	0.58	0.69	0.83	1.00	1.19	1.43	1.72	2.06	2.48
Diesel	30%	0.40	0.52	0.68	0.88	1.14	1.49	1.93	2.51	3.26	4.24	5.51

In addition, if increased revenues from the sale of diesel were spent on converting sections of existing gas stations into CNG fueling stations, in a 4-year transitional period a price increase of 10 percent would allow for the construction of nearly 657 dedicated CNG fuel sections, with a capacity of 2.63 billion m³ of CNG. This is equivalent to 2.63 million tons of diesel fuel. A 20 percent price increase would build nearly 1,455 dedicated CNG sections,

Figure 2
Diesel Fuel Price According to Different Assumptions



with capacity of 5.82 billion m³ equivalent to 5.82 million tons of diesel. A 30 percent increase could build nearly 2,415 dedicated sections, with 9.66-billion m³ capacity, equivalent to 9.66 million tons of diesel. Table 3 and Figures 3 and 4 presents this scenario.

Table 3
CNG Sections to be Constructed from Increased Revenue from Diesel Fuel Sales

Assumption	Unit	Years				Total
		1998–99	1999–00	2000–01	2001–02	
Increase of Revenue by 10%	Billion LE	0.26	0.59	0.98	1.46	3.28
	New CNG Stations	53	117	196	291	657
Increase of Revenue by 20%	Billion LE	0.53	1.23	2.15	3.37	7.28
	New CNG Stations	105	246	431	673	1,455
Increase of Revenue by 30%	Billion LE	0.79	1.93	3.54	5.82	12.08
	New CNG Stations	158	385	708	1,164	2,415

Figure 3

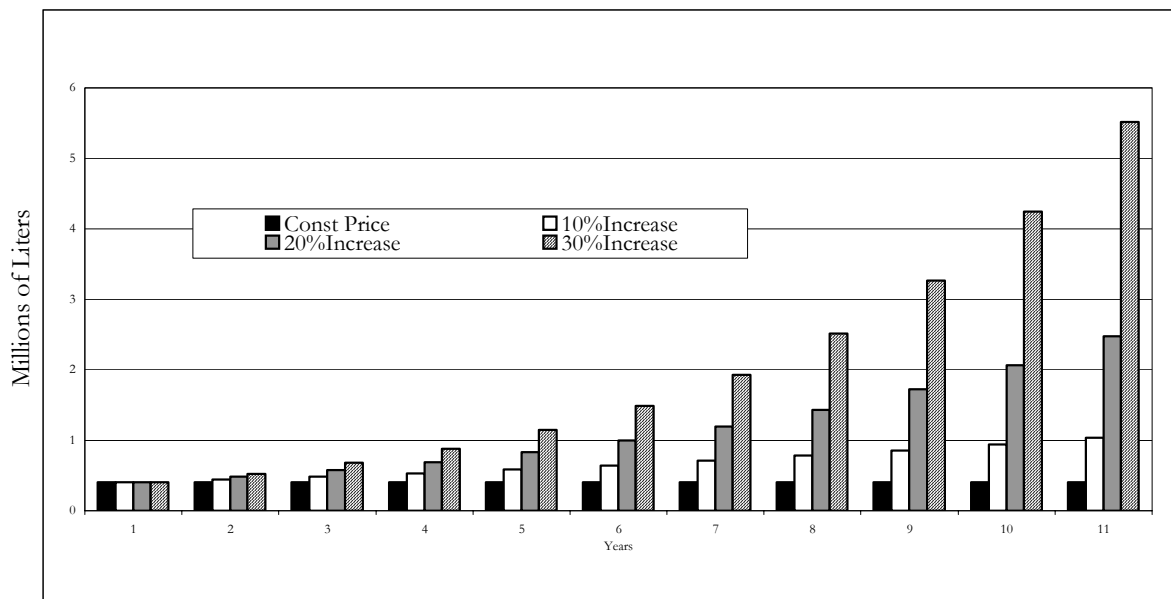
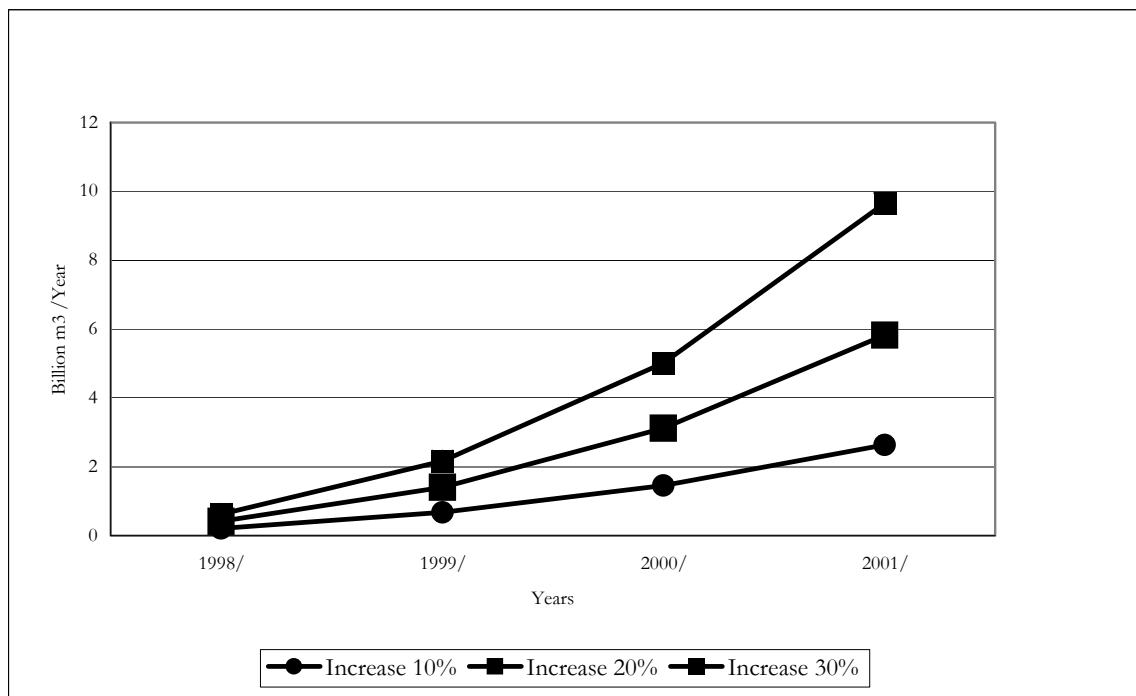
Number of CNG Stations that Could be Constructed from Increase of Diesel Fuel Price

Figure 4

Capacity of Constructed CNG Fuel Stations per Year

Recommendations

This study recommends the most gradual change to the price of diesel fuel—an increase of 10 percent annually. It also recommends supporting use of CNG through building new infrastructure, such as converting sections of gas stations to CNG fueling stations. Further, it recommends that the 10 percent increase in the price of diesel fuel be used to fund the cost of building this new CNG infrastructure. A smooth transition from diesel to CNG will enhance public acceptance of the lesser-known fuel.

This approach is three-fold: it decreases the government subsidy for diesel fuel, which will help to balance the budget; it supports the new natural gas industry; and it promotes the use of an environmentally friendly fuel.

This report assumes the amount of diesel fuel consumed will stabilize at about 6.2 million tons annually. The anticipated annual increase in demand for diesel fuel will be answered by increasing use of CNG. The various increases in the cost of diesel fuel were made for comparison, but the 10 percent annual price increase seems to be the most favorable scenario. A summary of this approach is shown below:

Program Implementation

The price of diesel fuel is now LE0.40/liter. At the recommended 10 percent price increase, over 4 years the price will rise to LE0.44/liter, LE0.48/liter, LE0.53/liter, and LE0.59/liter, as shown in Table 2.

The proceeds from the price increases, instead of reducing the government subsidy, will fund construction of nearly 600 CNG sections at regular gas stations (60 sections during the first year, 130 in the second, 180 in the third, and 220 in the fourth year). Actual construction or conversion, of course, will depend on related infrastructure being available. The total increase in revenue from the price increase will be about LE3 billion. The cost of constructing 600 CNG fuel stations should also be about LE3 billion. See Table 4 and Figure 5.

Consumption of diesel fuel should be about 6 million tons annually over the coming 4 years, approximately equal to total diesel consumption during 1997–98 (6.2 million tons).

Public awareness campaigns will be essential to educate the public about the benefits of using CNG as a substitute for diesel fuel. Information about the negative health and environmental impacts of burning diesel fuel and about the effect of the diesel subsidy on the government budget should be leading elements of those campaigns. The public should also be told that CNG-fueled vehicles last longer than those fueled with traditional liquid fuel, and the cost of maintaining and fueling such vehicles is lower.

Users of CNG should be rewarded with incentives such as tax reductions; reduced custom duties for CNG components, lower health insurance premiums, and lower vehicle license fees.

Table 4
Summary of Diesel Fuel/CNG Study

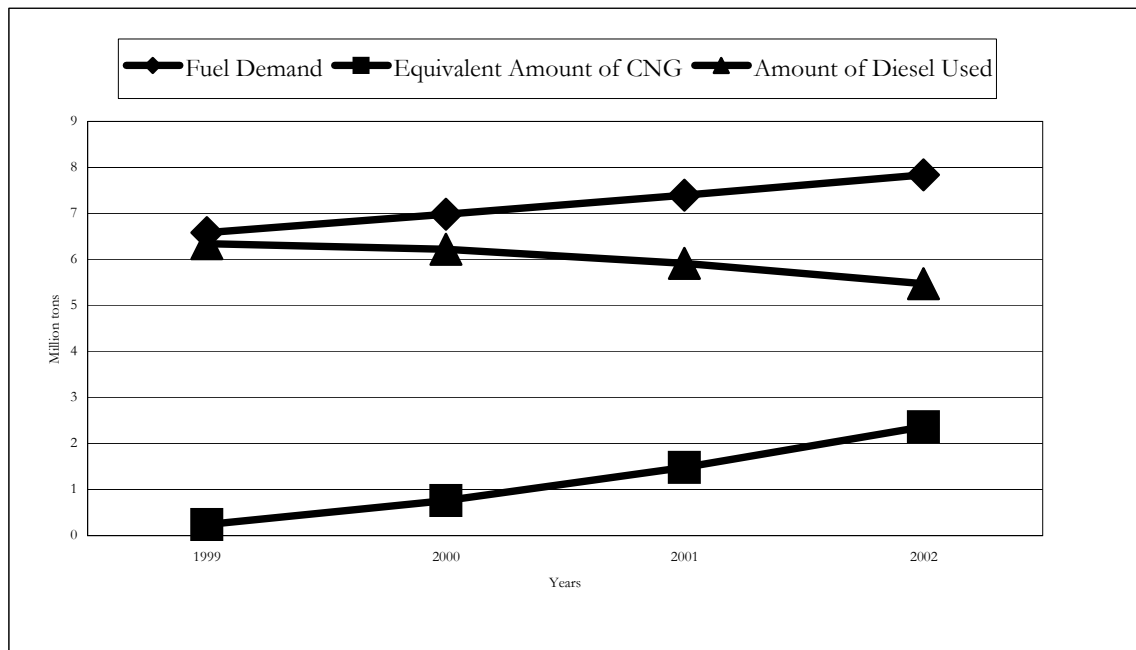
Items	Unit	Years			
		1998–99	1999–00	2000–01	2001–02
Gasoline Price	LE/Liter	1.00	1.00	1.00	1.00
Diesel Fuel Price	LE/Liter	0.45	0.50	0.55	0.60
Stations Constructed/Year	Stations	60	130	180	220
Total Number of CNG Stations	Stations	60	190	370	590
Annual Demand for Diesel Fuel	Million tons	6.59	6.98	7.40	7.84
Equivalent CNG Capacity	Million tons	0.24	0.76	1.48	2.36
Actual Consumption of Diesel	Million tons	6.35	6.22	5.92	5.48
Increase in Revenue	Billion LE	0.317	0.622	0.887	1.096
Accumulated Increase in Revenue	Billion LE	0.317	0.941	1.828	2.924
Cost of Constructing Stations	Billion LE	0.300	0.650	0.900	1.100
Accumulated Cost of Constructing Stations	Billion LE	0.300	0.950	1.850	2.950

Possibilities for the Future

Although not specifically part of the scope of work for this paper, it seems that clear that the following suggestions should be investigated. Each would help reduce dependence in the future on diesel fuel by substituting a clean-burning alternative energy source. It is suggested that the government consider:

- Converting high fuel consumption transportation systems, such as railways, to another type of fuel—CNG or electricity.
- Converting power generation systems and other diesel-fuel industries to CNG or to a renewable energy resource, such as solar or wind power.
- Generating electric power with nuclear fuel when a safe operating system is available and reliable methods to store and dispose of nuclear waste have been developed.
- Developing incentives to make purchasing CNG fuel vehicles more attractive economically when compared to diesel by reducing customs taxes on CNG-operated imported vehicles, especially heavy-duty and commercial vehicles such as trucks and buses.
- Decreasing registration, and licensing fees and taxes for low emissions vehicles that use alternative fuels.

Figure 5
Fuel Demand and Actual Amount of Diesel and CNG Consumed



- Making the use of CNG obligatory for public transportation, government vehicles, and privately owned urban fleets such as cabs and buses.
- Adopting an emissions test program that will encourage people to use vehicles that are environmentally friendly, such as those powered by CNG.

Although there is no way to predict with certainty, there appears to be sufficient profit margin between the actual cost of CNG and the current retail price to enable the price of natural gas to be stable for years to come.